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XXXII. *An Account of a Treatise, presented to the Royal Society, intituled, " Letters concerning Electricity ; in which the latest Discoveries upon this Subject, and the Consequences which may be deduced from them, are examined ; by the Abbé Nollet, Member of the Royal Academy of Sciences of Paris, Fellow of the Royal Society, of the Institute of Bologna, &c." extracted and translated from the French, by Mr. William Watson, F. R. S.*

Read May 17, 1753. **T**HE work before us contains 262 pages in 12mo, exclusive of the preface, and four copper plates, representing seventeen figures.

This treatise is the production of a great master upon the subject of electricity : he has already published two volumes expressly thereupon, besides several memoirs among the works of the Royal Academy of Sciences at Paris. For several years he has done me the honour of being my correspondent, and I have communicated several valuable papers from him to the Royal Society.

The discoveries made in the summer of the year 1752 will make it memorable in the history of electricity. These have opened a new field to philosophers,

phers, and have given them room to hope, that what they have learned before in their museums, they may apply, with more propriety than they hitherto could have done, in illustrating the nature and effects of thunder; a phenomenon hitherto almost inaccessible to their inquiries.

But to make the most certain advantage of these new discoveries, we should confine ourselves to facts; and if we do draw consequences from them, they should be immediate and necessary ones; for, whenever our discoveries seem to promise to be useful and important, we are apt to hope and expect great success from them: we must therefore be careful to restrain our imagination, or we shall fall into error.

These considerations have induced our author to examine with care, what may truly be concluded from the experiments proposed by Mr. Franklin of Philadelphia, and since carried into execution in France, and elsewhere, in relation to the electricity of the clouds during a storm; by weighing every circumstance, and comparing the greatness of the effects, which have been had in view, with the more than apparent insufficiency of the means, which have been employed to produce them. He thinks, he sees clearly, that the considering the electrification of pointed bodies as a proof of lessening the matter of thunder, is abusing a real discovery to flatter ourselves with a vain hope; and it is chiefly to dissipate this error, if it yet subsists, that determined our author to print, in the work before us, some reflexions, which he had made at first only for himself, and a few persons, to whom he was desirous of communicating his opinion.

Mr.

Mr. Franklin's treatise upon electricity contains a great many very curious experiments; but the deductions from them being different from those, which the Abbé Nollet has given upon the same subjects, it might be imagined, if he were silent upon this head, that he had given up his former opinions. The honour, which the Royal Academy of Sciences has done them, in publishing them in their Memoirs, and the kind reception, which the public has given them, has obliged him to re-examine these opinions, and to undertake their defence; more especially as he sees, that he has powerful reasons to support them. This has also been a motive for the present publication, which our author is desirous should be considered, less as a criticism upon Mr. Franklin's doctrine, than as a defence of his own.

In some parts of these letters, our author mentions an electricity, which is very often, and perhaps always, in our atmosphere, when there is no appearance of thunder. He speaks of this, as if he only suspected it, and, in a manner, as if it wanted confirmation. He was then unacquainted with some decisive experiments made upon this subject by Dr. le Monnier*, at St. Germain-en-laye, and which have been just published. He now considers, as a thing certain, that electricity is a very common meteor, which may manifest itself, when the weather is most serene;

* In a memoir read to the Royal Academy of Sciences at Paris, Nov. 15, 1752.

serene ; and that thunder is, strictly speaking, only one of its modifications, which renders it more sensible to us.

The Abbé Nollet's treatise contains nine letters ; six of which are addressed to Mr. Franklin, one to Mademoiselle Ardinghelli, who, when only sixteen years old, translated Dr. Hales's treatise of Hæmatics into Italian, and added thereto some very ingenious remarks ; one to Mr. Jallabert of Geneva, and one to Mr. Boze of Wittemberg : To these are added some experiments in electricity, made in support of opinions, laid down in this work, in the presence of Messieurs Bouguer, de Montigny, de Courtivron, d'Alembert, and le Roi, who were appointed by the Royal Academy of Sciences for that purpose.

In the first letter our author gives his correspondent Mademoiselle Ardinghelli an account of the discoveries in electricity in the year 1752 ; among which he takes particular notice of the experiment made on May 10, at Marly-la-ville, in consequence of Mr. Franklin's hypothesis ; wherein pointed non-electrics, supported by electrics *per se*, gave manifest signs of electricity during a thunder-storm. This experiment, in the letters to Mr. Collinson, Mr. Franklin had proposed, but, as far as may be judged, had not then carried into execution. The experiment of Marly-la-ville was soon after verified by Dr. le Monnier at St. Germain-en-laye, who found further, first, that the like effects were produced, whether the iron rods were pointed, or not ; and that it was indifferent, whether their position was horizontal, or not. Secondly, that thunder electrified not only iron, but also wood,

wood, living bodies, and other electrifiable substances. Thirdly, that it was not absolutely necessary to place these bodies at the tops of buildings; and that it was sufficient for them to be placed about four feet from the ground in an open situation, and at some distance from large buildings. Fourthly, that bodies electrified in this manner produced the like phenomena with those electrified by glass after the usual manner. It was afterwards discovered, that electrifiable bodies, thus disposed in open air, were sometimes electrified under thick clouds, but without thunder, lightning, or even without rain or hail.

The Abbé Nollet recommends, that these experiments should be made with circumspection, as he has been informed by letters from Florence and Bologna, that those, who have made them there, have had their curiosity more than satisfied by the violent shocks, which they have sustained, in drawing off the sparks from an iron bar electrified by thunder. One of these in particular says, that once, as he was endeavouring to fasten a small chain, with a copper ball at one of its extremities, to a great chain, which communicated with the bar at the top of the building, in order to draw off the electrical sparks by means of the oscillations of this ball, there came a flash of lightning, which he did not see, but which affected the chain with a noise like wild-fire. At that instant, the electricity communicated itself to the chain of the copper-ball, and gave the observer so violent a commotion, that the ball fell out of his hands, and he was struck backwards four or five paces. He never had been so much shocked by the experiment of Leyden.

From

From the experiment at Marly-la-ville, and those which have been made since, have been drawn two consequences ; one, that the matter of thunder, and that of electricity, are one and the same : the other, that, by the means of pointed iron rods, one might, without its doing any harm, draw off all the fulminating matter from a stormy cloud. But our author has shewn, that bodies being pointed are not absolutely necessary ; and is desirous, we should not too hastily believe, that mischiefs arising from thunder may be averted by the apparatus proposed. He thinks the means vastly too small for the greatness of the cause.

Our author's first letter to Mr. Franklin is an introduction to the five subsequent ones.

The second letter treats of the nature of the electric matter. In this its analogy with fire is considered and proved ; and our author takes notice, that Mr. Franklin, he imagines, who has certainly made some important discoveries into the properties of electricity, cannot but be dissatisfied with the editors of his work, for publishing, " that he exhibited to " our consideration an invisible subtil matter, disseminated throughout all nature, &c. which had hitherto escaped our observations." The latter part of which assertion is not strictly true ; as the considering the matter of fire, and that of electricity, to be one and the same, is a fundamental principle of what both the Abbé Nollet and myself formerly published upon this subject.

The third letter to Mr. Franklin contains several proofs, that glass is not impermeable to the electric matter.

matter. Some of the experiments of our author upon this subject I heretofore did myself the honour to lay before you ; and they are in my opinion fully conclusive.

The fourth letter to Mr. Franklin relates to several phænomena of the experiment of Leyden. In this letter it is examined, whether the effects of this experiment proceed from the glass phial, or from the non-electrics contained therein ; and experiments are produced to prove, that the power of giving a shock in an electrified phial of water, proceeds from the water in the phial, and not from the phial itself, as Mr. Franklin imagines. In this letter likewise is an examination of Mr. Franklin's opinion, that, in the charged phial, as much fire as is received by one of its surfaces is lost by the other.

The fifth letter to Mr. Franklin is in relation to the power of pointed non-electric bodies drawing off and throwing off electrical fire, at a much greater distance than obtuse bodies do of the same kind. Our author thinks, that Mr. Franklin has attributed more power to pointed bodies, than, upon experiment he finds to be true.

The sixth letter to Mr. Franklin is upon the analogy of thunder with electricity. This is a fact at present so well established, as to admit of no doubt. But our author cannot agree with Mr. Franklin in his opinion, “ that thunder is at present in the power of
“ men, and that we are able to dissipate it at our
“ pleasure : that an iron rod (such a one as Mr.
“ Franklin has directed, and such a one as has been
“ made use of) is sufficient to discharge of all its fire

“ a stormy cloud against which it is directed.” For his part he confesses, that he cannot believe it ; first, because he sees too great a disproportion between the effect and the cause : secondly, because the principle, which is given us to support this opinion, is not sufficiently established. He can hardly think, that the fulminating matter, contained in a cloud, capable of covering a great city, can be drawn off in a few minutes by a pointed bar, as thick as your finger. If even a number of these placed upon the tops of eminencies were only necessary to prevent the effects of thunder, would not the vanes and crosses at the tops of our steeples have been sufficient to procure us this advantage ? These buildings however, in all times, have not been exempted from the mischiefs of thunder. He despairs of our weak efforts ever being able to disarm the heavens.

Our author here gives us the representation and description of his apparatus for electrifying during the thunder : it differs in nothing essential from those, which we used last year.

In this letter are likewise consider'd the validity of Mr. Franklin's hypothesis of electric and non-electric clouds ; the former arising from the sea, the latter from the land ; their operation, upon their approaching one near the other ; the difference, according to Mr. Franklin, between electrical and common fire ; and several other parts of Mr. Franklin's doctrine.

The eighth letter is addressed to our worthy brother Professor Jallabert of Geneva ; and, among other curious particulars, inserts part of a letter, which our author had received from Mr. Jallabert, giving an

account of an experiment, which Mr. Jallabert had some time since made at the water-works at Geneva. An account of this experiment was communicated by myself to the Society ; and it has near relation to the experiment, which we made here in electrifying the river Thames six years ago. Mr. Jallabert consults the Abbé Nollet in relation to the solution of the phænomena of this experiment ; and the Abbé does me the honour now to give the same solution thereto, which I first gave to a similar experiment of Dr. le Monnier's, and laid before the Society in January * 1746, and since applied upon other occasions in illustrating the electrical circuit.

The ninth letter is addressed to Mr. Bosc, professor of mathematics and philosophy at Wittemberg ; and is in answer to one of Mr. Bosc, in which this gentleman expresses himself surprised, that so many ages have passed, without it having been discovered, that thunder electrifies bodies ; since it depends upon an experiment so simple, and which it is hardly possible to fail in, when you desire to repeat it under proper circumstances.

Upon this our author observes, that people in general only see the facts, and are ignorant of, or do not consider, the means, by which philosophers arrive at them ; nor perceive the circumstances, without which these phænomena could never have been made known to us ; and that Mr. Bosc will cease to be surprised, as he is so well versed in these phænomena, when he reflects upon what our author offers.

To

* See *Phil. Transf.* Vol. XLIV. p. 388.

To make the experiment in question, it is necessary that bodies should be supported by glass, silk, or resin, without touching any thing else communicating with what we now call non-electrics; without which, the signs of electricity, which are sought for, cannot manifest themselves.

To this experiment, therefore, a previous knowledge is required, of insulating bodies to be electrified; but where is the man who was acquainted with this fact thirty years ago? Before that period, it was not even guessed at by any one.

Since Mr. Gray discovered, that bodies must be insulated, to communicate to them a perceptible electric virtue, to what purpose could we set up iron bars under a stormy cloud? This thought could not have happened, but to those who had taken notice of the analogy between lightning and electricity, and upon whom this idea had made a strong impression. And no one could think seriously upon this analogy, but since the discovery of the experiment of Leyden, that is, since the year 1746. Before that time the electrification of bodies by thunder could not have been perceived, but by an accident very difficult to meet, on account of the conditions requisite.

Nevertheless it may be urged, that bodies, being really electrified, have shewn themselves in all ages*,
as

* I formerly took notice, that the electrical attraction had been observed so early, as to be mentioned by Theophrastus (see *Phil. Transf.* Vol. XLIV. p. 732); so its luminous appearance, though only considered as a meteor, is mentioned by Plutarch, in the life of Lyfander. Pliny, in the second book of his natural history, chap.

as historians both ancient and modern have made formal mention thereof. But to this it may be replied, that it was not enough to know the fact, unless people were enough acquainted with it to take it for what it really was; that is, the electric virtue: for without that, observations of this kind could have very little weight with

37, calls these appearances flares; and tells us, not only that they settled upon the masts, and other parts of ships, but also upon mens heads: ‘*Exsistunt (says that historian) stellæ et in mari terrisque. Vidi nocturnis militum vigiliis inhærere pilis pro vallo fulgorem effigie ea: et antennis navigantium, aliisque navium partibus, ceu vocali quodam sono insistunt, ut volucres sedem ex sede mutantes: . . . geminæ autem salutares, et prosperi cursus prænunciæ; quarum adventu, fugari diram illam ac minacem, appellatamque Helenam, ferunt. Et ob id Polluci et Castori id numen assignant, eosque in mari deos invocant. Hominum quoque capiti vespertinis horis, magno præfagio circumfulgent.*” But (adds he) all these things are ‘*incerta ratione, et in naturæ majestate abdita.*’

Seneca, in his *Natural Questions*, chap. 1. takes notice of the same phænomenon. ‘*Gylippo (says he) Syracusas petenti visa est stella super ipsam lancem constitisse. In Romanorum castris visa sunt ardere pila, ignibus scilicet in illa delapsis.*’

Cæsar de Bello Africano, cap. 6. *edit. Amstel. 1686.* We here find them attending a very violent storm. ‘*Per id tempus fere Cæsaris exercitui res accidit incredibilis auditu; nempe Virgiliorum signo confecto, circiter vigilia secunda noctis, nimbus cum faxea grandine subito est exortus ingens. . . . Eadem nocte V legionis pilorum cacumina sua sponte arserunt.*’

Livy, chap. 22. mentions two similar facts: ‘*In Sicilia militibus aliquot spicula, in Sardinia in muro circumeunti vigilias equiti, scipionem, quem in manu tenuerat, arsisse, et litora crebris ignibus fulsisse.*’

These appearances are called by both French and Spaniards inhabiting the coasts of the mediterranean, *St. Helme* or *St. Telme’s*

with any person engaged in the inquiry. At present, indeed, when we know, from the experiment of Marly-la-ville, that a stormy cloud is a great electric mass, the action of which extends itself sensibly even to bodies, which are upon the surface of the earth, we must agree, by reflecting on them, that the lights, which have been seen upon the crosses placed on the tops of several steeples, those, which the Roman soldiers said they had observed at the end of their pikes, and those lambent flames, which appear upon the masts of ships, which mariners call St. Helmo's fire, are so many electrical phænomena. But until the moment that this experiment was made, which open'd our eyes with regard to the possibility and nature of these marvellous effects, these appearances were regarded either as popular illusions, or false prodigies, or even as luminous vapours, which might be ranged in the class of *phosphori*. Moreover, as these were seen but seldom, if ever we had been tempted to attribute them to the influence of stormy clouds, we might have been dissuaded therefrom, by considering the little agreement there is, between the rarity
of

fires; by the Italians, the fires of St. Peter and St. Nicholas, and are frequently taken notice of by the writers of voyages.

If some late accounts from France are to be depended upon, we are informed, that at Plauzet it has been observed for time immemorial; and M. Binon, the curé of the place, bears his testimony of the truth, that, for twenty-seven years, which he has resided there in that capacity, in great storms, accompanied with black clouds, and frequent lightnings, the three pointed extremities of the cross of the steeple of that place appear surrounded with a body of flame; and that, when this phænomenon has been seen, the storm was no longer to be dreaded, and calm weather returned soon after.

of these effects, and the frequency of the causes, which might produce them.

We see, therefore, how important it is to describe exactly the phenomena we observe: otherwise, how long may it be, before we can deduce any real instruction from those, which we have been informed of in a negligent and superficial manner? We have heard all our lives of St. Helmo's fire, of those which the antients call Castor and Pollux, and of the comazants of our mariners. But, from what we have had related to us, and from what we have read, who could have been prevailed upon to range them with electrical phenomena? We have heard them represented, as thin lambent shining lights, a kind of phosphoreal vapour: but there is a passage in the memoirs of the Count de Forbin, quoted by our author, wherein mention is made of St. Helmo's fire; which if any one, well versed in the phenomena of electricity, had carefully attended to and considered a few years ago, he might have prognosticated success to Mr. Franklin, when he proposed his experiment upon thunder. " In the night (says the author of those memoirs) on a sudden it became exceedingly dark, and thunder'd and lightened most dreadfully. As we were threatened with the ship's being torn to pieces, I ordered the sails to be taken in: We saw, upon different parts of the ship, above thirty St. Helmo's fires: Among the rest, there was one upon the top of the vane of the main-mast, which was more than a foot and half in height. I ordered one of the sailors to take it down: When this man was on the top, he heard this fire; its noise resembled that of fired wet gunpowder: I
" ordered

“ ordered him to lower the vane, and come down;
 “ but scarce had he taken it from its place, but
 “ the fire left it, and fixed itself upon the top of
 “ the mainmast, from which it was impossible to
 “ remove it; and continued there a considerable time,
 “ until it went out by little and little, &c.”

If all the authors, who have taken notice of St. Helmo's fire, had spoken of it as this just quoted, philosophers might have reproached themselves for its having been so long before they had a just idea thereof, and for their not having shewn the principle upon which it depended. But how few historians are there, who could have related this fact with circumstances so proper to put us in a right train, as those just mentioned?

“ And here I cannot but observe, as I am convinced, that the matter of thunder and that of electricity are one and the same, how vast an idea must the attending to the before-mentioned passage excite in the mind of persons, accustomed to the phænomena of electricity? How immense a quantity of it must they conceive to have been at that time in the atmosphere surrounding the ship, and within the verge of its action, to furnish more than thirty St. Helmo's fires; the same, in fact, which we see at the ends of our conductors in electrifying, one of which was more than a foot and half in height? At this time, and under these circumstances, the masts, yards, and every part of the ship, I consider as conductors of electricity, between the, at this time electrified, atmosphere, and the sea: and tho', being of a vegetable nature, and, if dry, even of the worst kind for this purpose,

“ pose, they conducted electricity much less perfectly
 “ than metal under the like circumstances would
 “ have done, I doubt not, but that they were greatly
 “ instrumental in averting the danger, with which
 “ the ship was threatened.

“ Upon these considerations, I do not scruple to
 “ recommend, as Mr. Franklin has done, communi-
 “ cations of metal between the spindles and iron-
 “ work at the tops of the masts of ships, and the sea;
 “ or, which will answer the same purpose, the bilge
 “ water in the well. This can be liable to little
 “ objection, as the doing it is neither difficult, nor
 “ expensive; an iron wire, of the thickness of a goose-
 “ quill, conducting electricity more readily than any
 “ piece of timber, however large; and these masts
 “ do it so much the worse, as they are of a resinous
 “ nature.

“ From attending to these phænomena, we every
 “ day see more and more the perfect analogy (to
 “ compare great things with small) between the
 “ highly electrified glass jar, in the experiment of
 “ Leyden, and a cloud replete with the matter of
 “ thunder. But more of this possibly upon some
 “ future occasion.

“ Though the number and continuance of the St.
 “ Helmo’s fires, in the passage before-mentioned,
 “ probably tended greatly to preserve the ship from
 “ the destruction, with which it was then threatened,
 “ yet the cause may be too great, and come on too
 “ fast, to be lessened enough by these means to avert
 “ the mischief. Thus in the account, published in
 “ the * *Philosophical Transactions*, from Captain John
 “ Waddel,

“ Waddel, his ship was almost beaten to pieces by
 “ the thunder and lightning: although, as he expresses
 “ himself, there were sundry large comazants over
 “ head, some of which settled on the spindles on
 “ the topmast-heads, and burnt like very large
 “ torches. When this account was written, these
 “ phænomena were only considered as the presages
 “ or attendants of a storm, and no sort of inference
 “ proposed from them.”

But to return to our author: His work closes with a series of experiments, intended to demonstrate the validity of the conclusions exhibited therein. These merit the particular attention of those conversant in these matters; but I must refer you here to the work itself, and only observe, that some of the experiments are made *in vacuo*, and are of the same kind with those which I communicated to the Royal Society in February 1752; and which have been since published in the *Philosophical Transactions* *.

Upon the whole, I think the treatise before us a very valuable one, as it gives us the still riper thoughts of an able writer upon a difficult, and, till very lately, an almost unknown, subject; of one, who, besides his inquiries into this part of philosophy, has a great compass in the knowledge of nature, and is therefore well qualified to investigate her phænomena.

* Vol. XLVII. p. 363, et seq.